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Comparison among different decommissioning funds methodologies for nuclear installations

Final Report

Country Report Germany

on behalf of the European Commission
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Country Report (WP 1/WP 3)

Germany

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Wuppertal, 31 October 2006

Contents

Summary

According to the German Atomic Energy Act (AtG), statutory ordinances promulgated on the basis of the AtG, as well as general administrative provisions, and following the 'Polluter Pays Principle', the licensees are responsible for any decommissioning activities, are free to decide on the decommissioning strategy they would like to follow, and have to bear the respective costs (the Federal Government still remains responsible for the final disposal but can charge the licensees for any activities in this context, and can ask subordinated authorities or third parties to build and operate a repository). Because of these liabilities, private operators of nuclear installations in Germany are obliged by law to set up accruals to cover future decommissioning costs. The main legal basis for this is the German commercial code (HGB: Handelsgesetzbuch). In addition, for public stock companies, the respective commercial code for public stock companies (AktG: Aktiengesetz) has to be applied. On the corporate group level, the corporate groups to which the private operators belong, set up provisions according to international accounting standards (US-GAAP, IAS/IFRS). There are no restrictions with regard to the investment of these internal funds.

In contrast, public owners of nuclear installations do not set up provisions but pay their (share in) decommissioning costs from the current budget.

Special financial arrangement exist for facilities with mixed public-private ownership, which clarify how much of the costs have to be born by the public and how much by the private organisations. There is a tendency to limit the financial contributions by private organisations in such arrangements, so that the public has to bear cost overruns.

In the past, there have been several proposals to install a well-governed external decommissioning funds. However, one important consequence of the mutual agreement between Government and NPP operators of 14 June 2000 (nuclear phase-out agreement) and a revision of German tax law in 1999 is, that today, there is hardly any policy space left for changes in the current decommissioning financing system for privately-owned nuclear installations anymore. Furthermore, the German Federal Government seems to be fully convinced that the existing decommissioning financing system in place is functioning well in principle.

Nevertheless, because of possible problems of financial insecurity inherent in the current system of internal unrestricted funds, it is recommended to think at least about the implementation of additional regulations and restrictions with regard to

- the disclosure of data and information,
- a possible bankruptcy of the licensee, and,
- the investment of internal funds by private companies

for the case that the current decommissioning financing system in Germany was maintained. More detailed recommendations for the European and national level will be developed within the final report of this project following the considerations of the financial risk analysis, which will be a main part of this project.

1 Introduction and overview

In Germany, the **legal bases** for licensing procedures for the operation and decommissioning of nuclear facilities are the Atomic Energy Act (AtG), statutory ordinances promulgated on the basis of the AtG, as well as general administrative provisions (BMU 2005). Section 7 of the AtG contains the basic requirements for the licensing of dismantling of a nuclear installation and all measures leading to the plant or the site being released from nuclear regulatory control. Section 9 and 9a contain the respective requirements with regard to the nuclear fuel cycle and radioactive waste management. The implementation of licensed decommissioning activities of nuclear installations is monitored by the supervising authority. Since decommissioning work needs a special decommissioning license, a transition from the operational license state to the decommissioning license state is needed. For some actions, which are needed both for operation and for decommissioning, it is advantageous for the operators to handle them under the operational license (e.g., spent fuel and operational waste management, or shut down of circuits). There is no need for a new license if the removal of the spent fuel is already a part of the operational license (Petrasch/Luyten 2001).

According to this public law, and following the 'Polluter Pays Principle', the **licensees are responsible for any decommissioning activities** and have to bear the respective costs (the Federal Government still remains responsible for the final disposal but can charge the licensees for any activities in this context, and can ask subordinated authorities or third parties to build and operate a repository). Because of these liabilities, **private operators of nuclear installations in Germany are obliged by law to set up accruals to cover future decommissioning costs (internal, unrestricted funds)**. The main legal basis for this is the German commercial code (HGB: Handelsgesetzbuch). In addition, for public stock companies, the respective commercial code for public stock companies (AktG: Aktiengesetz) has to be applied. On the corporate group level, the corporate groups to which the private operators belong, set up provisions according to international accounting standards (US-GAAP, IAS/IFRS). In contrast, **public owners of nuclear installations do not set up provisions** but pay their (share in) decommissioning costs from the **current budget**.

The discussion on decommissioning financing cannot be fully separated from the discussion on the **nuclear phase-out agreement of 14 June 2000** by the Federal Government and the corporate groups of the NPP operators. This nuclear agreement limits power generation of the different commercial NPPs up to specific amounts of kWh defined. In practice, according to own estimates by Wuppertal Institute, this regulation allows an undisturbed plant lifetime of 34 to 35 years on average as long as nuclear security requirements are fulfilled, which equals more or less technical-economic lifetimes usually assumed for such type of plants. Furthermore, this agreement makes dismantling timeframes more predictable as long as the agreement will be valid and the direct dismantling strategy will be preferred (cf. Irrek 2005, and DIW/WI/IAT 2004, on which Irrek 2005 is based on).

One important change in the Atomic Energy Act following the agreement between Government and NPP operators was the prohibition of transferring spent fuel to re-

processing plants after 1 July 2005. Therefore, direct storage and disposal remains the only option for spent fuel since then, which has decreased costs substantially. Finally, the construction of a new NPP is prohibited, too.

The nuclear installations in Germany currently in operation, shut down, in the process of decommissioning or already fully decommissioned are listed in Table 1 (with the exception of the storages for radioactive waste). Furthermore, Table 1 shows which facilities have been analysed in more detail in the context of this project. In total, nuclear installations in Germany can be divided into the following categories:

- 30 commercial nuclear power plants of which are 17 in operation, 2 in safe enclosure and 11 in the process of decommissioning
- 6 prototype reactors (demonstration plants) of which 4 are in the process of decommissioning and 2 are already fully dismantled
- 46 research reactors of which are 14 in operation, 3 in safe enclosure, 8 in the process of decommissioning and 21 already fully dismantled
- 17 storages for radioactive waste at the NPP sites
- 13 other nuclear facilities (6 fuel fabrication facilities, 1 enrichment facility, 1 reprocessing plant, 4 research facilities, and one other nuclear installation) of which are 2 in operation, 6 in the process of decommissioning and 5 already fully dismantled
- one uranium mine in the process of decommissioning.

Table 1 Overview on nuclear installations in Germany (Status: May 2006)

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reac-tors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percent-age of shares held*** [%]	De-comm. started in year	De-comm. stage****	Ana-lysed in this report
Operating nuclear power plants												
Neckarwes-theim-1	GKN 1	DE	NPP	840	26.05.76	1976 - today	GKN GmbH	EnBW (EDF)	99.8			X
Neckarwes-theim-2	GKN 2	DE	NPP	1365	29.12.88	1989 - today	GKN GmbH	EnBW (EDF)	99.8			X
Philippsburg-1	KKP 1	DE	NPP	926	09.03.79	1980 - today	EnBW Kraft-werke AG	EnBW (EDF)	100			X
Philippsburg-2	KKP 2	DE	NPP	1458	13.12.84	1985 - today	EnBW Kraft-werke AG	EnBW (EDF)	100			X
Grafenrheinfeld	KKG	DE	NPP	1345	09.12.81	1982 - today	E.ON Kernkraft GmbH	E.ON	100			X
Gundremmin-gen-B	KRB-B	DE	NPP	1344	09.03.84	1984 - today	Kernkraftwerk Gundremmingen GmbH	RWE / E.ON	75.0 / 25.0			X
Gundremmin-gen-C	KRB-C	DE	NPP	1344	26.10.84	1985 - today	Kernkraftwerk Gundremmingen GmbH	RWE / E.ON	75.0 / 25.0			X
Isar-1	KKI 1	DE	NPP	912	20.11.77	1979 - today	E.ON Kernkraft GmbH	E.ON	100			X
Isar-2	KKI 2	DE	NPP	1475	15.01.88	1988 - today	E.ON Kernkraft GmbH	E.ON	75.0			X
Biblis-A	KWB A	DE	NPP	1225	16.07.74	1975 - today	RWE Power AG	RWE	100			X
Biblis-B	KWB B	DE	NPP	1300	25.03.76	1977 - today	RWE Power AG	RWE	100			X
Emsland	KKE	DE	NPP	1400	14.04.88	1988 - today	Kernkraftwerk Lippe-Ems GmbH (KLE)	RWE / E.ON	87.5 / 12.5			X

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reac-tors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percent-age of shares held*** [%]	De-comm. started in year	De-comm. stage****	Ana-lysed in this report
Grohnde	KWG	DE	NPP	1430	01.09.84	1985 - today	Gemeinschaftsk-ernkraftwerk Grohnde GmbH & Co.oHG	E.ON	83.3			X
Unterweser	KKU	DE	NPP	1410	16.09.78	1979 - today	E.ON Kernkraft GmbH	E.ON	100			X
Brokdorf	KBR	DE	NPP	1440	08.10.86	1986 - today	Kernkraftwerk Brokdorf GmbH &Co OHG	E.ON / Vattenfall	80.0 / 20.0			X
Brunsbüttel	KKB	DE	NPP	806	23.06.76	1977 - today	Kernkraftwerk Brunsbüttel GmbH & Co.oHG (KKB)	Vattenfall / E.ON	66.7 / 33.3			X
Krümmel	KKK	DE	NPP	1316	14.09.83	1984 - today	Kernkraftwerk Krümmel GmbH & Co.oHG (KKK)	Vattenfall / E.ON	50.0 / 50.0			X
Nuclear Power Pants and Prototypes allready shut down, decommmissioned or in the process of decommissioning												
Kompakte nat-riumgekühlte Kernanlage	KNK II	DE	NPP	21	10.10.77	1979 – 1991	Forschungszent-rum Karlsruhe GmbH				-2	X
Mehrzweckfor-schungs-reaktor	MZFR	DE	NPP	57	29.09.65	1966 – 1984	Forschungszent-rum Karlsruhe GmbH				-3	X
Gundremmin-gen-A	KRB-A	DE	NPP	250	14.08.66	1967 – 1977	Kernkraftwerk Gundremmingen GmbH				-3	
Heissdampfre-aktor Gross-welzheim	HDR	DE	NPP	25	14.10.69	1970 – 1971	Forschungszent-rum Karlsruhe GmbH				-3	
Niederaichbach	KKN	DE	NPP	106	17.12.72	1973 – 1974	Forschungszent-rum Karlsruhe GmbH				-3	X

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reactors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percentage of shares held*** [%]	Decomm. started in year	Decomm. stage****	Analysed in this report
Versuchsatomkraftwerk Kahl	VAK	DE	NPP	16	13.11.60	1962 – 1985	VAK	Advent International via NUKEM Gruppe	100		-3	
Rheinsberg	KKR	DE	NPP	70	11.03.66	1966 – 1990	EWN GmbH				-3	X
Greifswald-1	KGR 1	DE	NPP	440	03.12.73	1974 – 1990	EWN GmbH				-3	X
Greifswald-2	KGR 2	DE	NPP	440	03.12.74	1975 – 1990	EWN GmbH				-3	X
Greifswald-3	KGR 3	DE	NPP	440	06.10.77	1978 – 1990	EWN GmbH				-3	X
Greifswald-4	KGR 4	DE	NPP	440	22.07.79	1979 – 1990	EWN GmbH				-3	X
Greifswald-5	KGR 5	DE	NPP	440	26.03.89	1989 - 1989	EWN GmbH				-3	X
Lingen	KWL	DE	NPP	252	31.01.68	1968 – 1977	Kernkraftwerk Lingen GmbH	RWE	99		2	
Stade	KKS	DE	NPP	672	08.01.72	1972 - 2003	Kernkraftwerk Stade GmbH & Co.oHG	E.ON / Vattenfall	66.7 / 33.3		0	X
Obrigheim	KWO	DE	NPP	357	22.09.68	1969 - 2005	KWO Obrigheim GmbH	EnBW (EDF)	100		0	X
Arbeitsgemeinschaft Versuchsreaktor Jülich	AVR	DE	NPP	15	26.08.66	1969 – 1988	EWN GmbH				-1	X
Thoriumhochtemperaturreaktor	THTR-300	DE	NPP	308	13.09.83	1987 – 1988	HKG	RWE	31		-1	X
Würgassen	KWW	DE	NPP	670	22.10.71	1975 – 1994	E.ON Kernkraft GmbH	E.ON	100		0-3	X
Mülheim-Kärlich	KMK	DE	NPP	1302	01.03.86	1987 - 1988	RWE Power AG	RWE	100		0	X

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reactors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percentage of shares held*** [%]	Decomm. started in year	Decomm. stage****	Analysed in this report
Operating Research Reactors												
SUR Furtwangen	SUR-FW	DE	RR	1,0E-07 MWth	28.06.73	- today	Fachhochschule Furtwangen					
SUR Stuttgart	SUR-S	DE	RR	1,0E-07 MWth	24.08.64 / 12.06.69 (removal in 1969)	- today	Universität Stuttgart, Institut für Kernenergetik und Energiesysteme					
SUR Ulm	SUR-U	DE	RR	1,0E-07 MWth	01.12.65	- today	FH Ulm, Labor für Strahlenmesstechnik und Reaktortechnik					
Hochflussneutronenquelle München/Garching	FRM-II	DE	RR	20 MWth	02.03.04	25.04.05 - today	Technische Universität München					X
Berliner Experimentier-Reaktor II	BER-II	DE	RR	10 MWth	09.12.73	- today	Hahn-Meitner-Institut					
SUR Berlin	SUR-B	DE	RR	1,0E-07 MWth	26.07.63	1963 - 2000	TU Berlin, Institut für Energietechnik, Fachgebiet Kerntechnik					
SUR Hannover	SUR-H	DE	RR	1,0E-07 MWth	09.12.71	- today	Universität Hannover Institut für Werkstoffkunde					
DIDO	FRJ-2	DE	RR	23 MWth	14.11.62	- today	Forschungszentrum Jülich GmbH					X
SUR Aachen	SUR-AA	DE	RR	1,0E-07 MWth	22.09.65	- today	RWTH Aachen, Institut für Elektrische Anlagen und Energiewirtschaft					

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reactors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percentage of shares held*** [%]	Decomm. started in year	Decomm. stage****	Analysed in this report
Forschungsreaktor Mainz	FRMZ	DE	RR	0,1 MWth	03.08.65	- today	Universität Mainz, Institut für Kernchemie					
Ausbildungskernreaktor	AKR / AKR-2	DE	RR	2,0E-06 MWth	28.07.78/ 22.03.05	- today	Technische Universität Dresden, Institut für Energietechnik					
Forschungsreaktor Geesthacht-1	FRG-1	DE	RR	5 MWth	23.10.58	- today	GKSS Forschungszentrum Geesthacht GmbH					X
SUR Kiel	SUR-KI	DE	RR	1,0E-07 MWth	29.03.66	1966 - 1999	Fachhochschule Kiel					
Research Reactor in the process of decommissioning												
Forschungsreaktor-2	FR-2	DE	RR	44 MW_{th}	07.03.61	Until 21.12.81	Forschungszentrum Karlsruhe GmbH				2	X
TRIGA Heidelberg I	TRIGA HD I	DE	RR	0,25 M W_{th}	26.08.66	Until 31.03.77	Deutsches Krebsfoschungszentrum					
TRIGA Heidelberg II	TRIGA HD II	DE	RR	0,25 M W_{th}	28.02.78	Until 30.11.99	Deutsches Krebsfoschungszentrum					
Forschungsreaktor München	FRM	DE	RR	4 MW_{th}	31.10.57	Until 28.07.00	Technische Universität München					
Forschungsreaktor Neuherberg	FRN	DE	RR	1 MW_{th}	23.08.72	Until 16.12.82	GSF, Forschungszentrum für Umwelt und Gesundheit				2	
Forschungsreaktor Frankfurt - 2	FRF-2	DE	RR	1 MW_{th}	Not critical	No operation	Johann-Wolfgang-Goethe-Universität				2	

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reactors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percentage of shares held*** [%]	Decomm. started in year	Decomm. stage****	Analysed in this report
Forschungs- und Messreaktor Braunschweig	FMRB	DE	RR	1 MW_{th}	03.10.67	Until 19.12.95	Physikalisch-Technische Bundesanstalt					
TRIGA-Hannover	TRIGA MHH	DE	RR	0,25 M W_{th}	31.01.73	Until 18.12.96	Medizinische Hochschule Hannover					
Forschungsreaktor MERLIN	FRJ-1	DE	RR	10 MW_{th}	23.02.62	Until 22.03.85	Forschungszentrum Jülich GmbH				-2	X
Rossendorfer Forschungsreaktor	RFR	DE	RR	10 MW_{th}	16.12.57	Until 27.06.91	Verein für Kernforschungstechnik und Analytik				-3	
Zittauer Lehr- und Forschungsreaktor	ZLFR	DE	RR	1,0E-05 MW_{th}	25.05.79	Until 24.03.05	Hochschule Zittau/Görlitz (FH) FB Maschinenbauwesen					
Forschungsreaktor Geesthacht-2	FRG-2	DE	RR	15 MW_{th}	16.03.63	Until 28.01.93	GKSS Forschungszentrum Geesthacht GmbH				-3	X
Research Reactors already fully decommissioned												
21 research reactors had been already fully decommissioned by July 2005.												
Other nuclear facilities												
Uranan-reicherungs-anlage Gronau	URENCO	DE	Enrichment facility			- today	Urenco Deutschland GmbH	Urenco Ltd. (of which E.ON Kernkraft owns)	100 (33.3)			X
Brennelement-Fertigungsanlage Lingen	ANF	DE	Fuel fabrication plant			- today	Advanced nuclear fuels GmbH (100% owned by AREVA NP)	AREVA / Siemens	66.0 / 34.0			X
Wiederaufarbeitungsanlage Karlsruhe	WAK	DE	Reprocessing plant			1971 - 1990	WAK GmbH (100% owned by EWN GmbH)				-3	X

Nuclear facility	Short name	Country	Kind of facility*	Output (Power in MW_{el} for NPP)	First criticality (in case of reac-tors)	Operational period	Operating company	Name of quoted companies holding shares in the nuclear facitlity, if any**	Percent-age of shares held*** [%]	De-comm. started in year	De-comm. stage****	Ana-lysed in this report
Diverse JRC facilities, Karls-ruhe	ITU-JRC	DE	Re-search facilities				Institute for Tran-suranium Ele-ments (ITU/JRC)					X
Uranerzberg-bau Wismut	Wismut	DE	Uranium mine			1947 - 1990	Wismut GmbH					X
11 further nuclear facilities in operation, shut down, in the process of decommissioning or already fully decommissioned.												

* Kind of facility: NPP = Nuclear Power Plant RR = Research Reactor

** Quoted: quoted on the stock exchange. Quoted companies directly or indirectly owning the nuclear installation or at least a part of it.
*** Percentage of direct or indirect shares held by companies quoted on the stock exchange.

**** Decomm. = Decommissioning. Decommissioning stages:
Operating: Still in operation; not shut down yet
0 Decommissioning announced
1 Decommissioning to stage 1
2 Decommissioning to stage 2
3 Decommissioning to stage 3
3* Decommissioning to stage 3 without civil engineering
-x Decommissioning in progress towards stage x
Unfortunately, this information was not available for all nuclear facilities in Germany.

Source: Bundesamt für Strahlenschutz (BfS)(July 2005); http://ec.europa.eu/energy/nuclear/decommissioning/status_en.htm (4 September 2006); annual reports and internet pages of operators and shareholders.

2 Decommissioning strategies and costs

2.1 Current and past decommissioning activities

2.1.1 Current and past decommissioning experiences and strategies

Germany is one of the European countries with already many experiences in dismantling of nuclear power plants and other nuclear installations (cf. Table 1). The nuclear operators (licensees) are responsible for the choice of the decommissioning strategy. They take radiation protection, employment/know-how and financial aspects into account. In the past, after having removed all spent fuel, for several nuclear facilities the 'safe enclosure' option was chosen, while for other plants, direct dismantling was preferred. From the perspective of the Federal Ministry for Environment as the superior supervising authority, several employment/know-how, risk, cost and radiation protection aspects are arguments in favour of the direct dismantling strategy.

2.1.2 Calculation of decommissioning costs of commercial NPP

In Germany, decommissioning costs of commercial nuclear power plants are usually calculated following plant-specific assumptions with regard to the dismantling, decontamination, demolition and waste management (including spent fuel management) strategy chosen by the lincensees. There are substantial differences in the way waste management and dismantling/decontamination/demolition costs are calculated (cf. Irrek 1996; information by the nuclear authority BfS; WI/ÖI 2000; Mertin/Hortmann 2001; Petrasch/Luyten 2001).

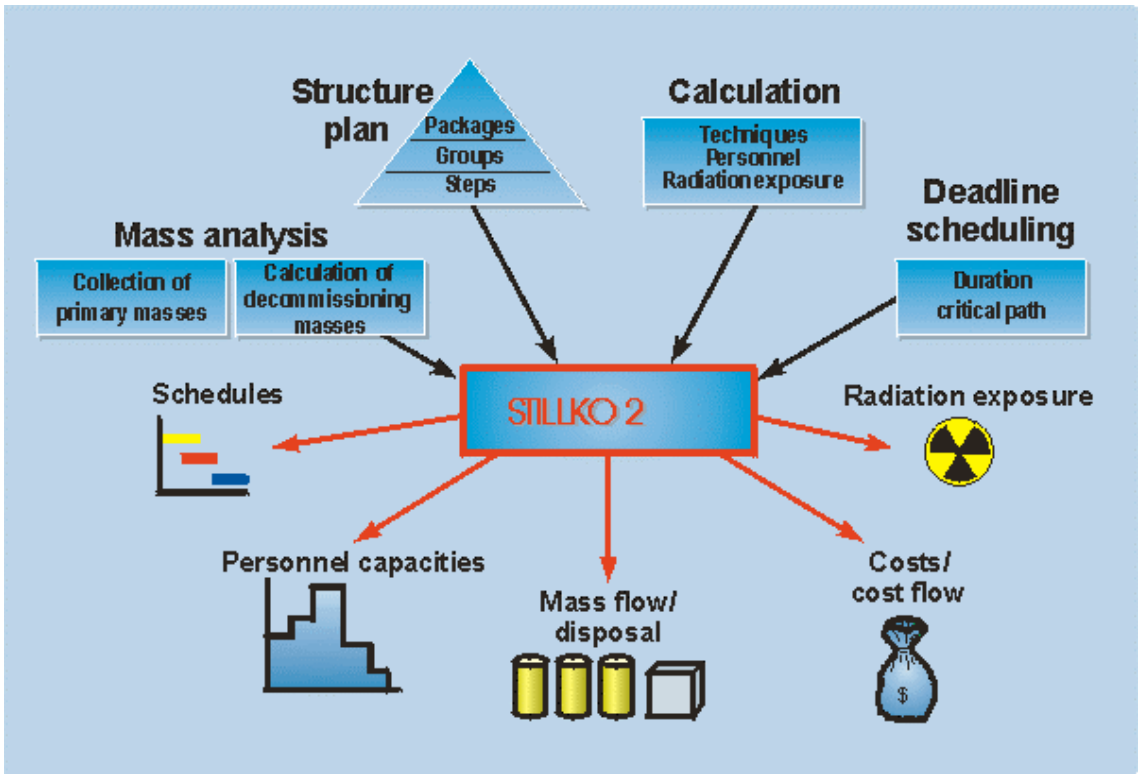
As far as possible, estimates of waste management costs are based on existing contracts with reprocessing (until 1 July 2005) or storage facilities, and contracts with transport firms. Furthermore, expected costs of conditioning and packaging and contributions to the construction and operation of final disposal facilities according to the operator's share in expected waste volumes have to be taken into account.
For final disposal, the German Ministry for Environment prefers to have one repository in deep geological formations for all types of radioactive waste. Criteria for the search of such a repository have been developed by a group of experts (AkEnd 2002). According to some experts, costs of such a repository might accumulate to 5 billion Euro which have to be born by the different operators according to their share in expected waste volumes. The costs of identifying a suitable site for a final disposal according to the criteria and procedures suggested by (AkEnd 2002) are estimated at 700 million Euro (Irrek 2004). However, a detailed cost estimate fors such a repository does not yet exist. Therefore, final disposal cost is a major uncertainty in any cost calculation of nuclear facilities in Germany. Furthermore, even if a final disposal had been identified and a sound cost estimate for the final disposal existed, actual unit cost, which occur many years or even decades later, could exceed estimated ones. This could be a consequence of improvements in disposal facilities, more stringent nuclear security re-

quirements or a reduction in the volume of wastes. In the meantime, calculations are based on older cost estimates by the nuclear authority BfS assuming the following costs for the different final disposal sites: 2.3 billion Euro for preparation and construction and 32 million Euro/year of operation for a repository for HLW (Gorleben); 1.4 billion Euro for preparation and construction and 35 million Euro/year of operation for a repository for ILW/LLW (Konrad); up to 1.5 billion Euro for the closure of an old repository in East Germany (Morsleben).
In 2000, Öko-Institut estimated the costs of direct disposal of spent fuel (i. e., without reprocessing) at about 1,327 Euro/kg HM, with a range between 913 and 1,741 Euro/kg HM (WI/ÖI 2000). Petrasch and Luyten (2001) expect final repository costs in Germany of about 18,000 Euro/m^3.

For each NPP, costs of dismantling, decontamination and demolition are usually estimated with the help of the NIS-STILLKO software on behalf of VGB PowerTech, the association of power plant operators. NIS-STILLKO has been extensively used not only in Germany, but also in many other European countries, including Italy. Figure 1 presents a schematic overview of this software tool. Methodology and framework conditions of the calculations by NIS are set in accordance with VGB Powertech, taking into account the many different aspects and inter-related parameters of the complex decommissioning process. Since many years, NIS has carried out a detailed deterministic, budgetary cost estimate for a typical 800 MWel BWR (like Brunsbüttel) or 1,200 MWel PWR (like Biblis A), further developed and updated from time to time taking experiences with decommissioning activities in practice into account. This NIS model calculation takes all activities after the final shutdown into account. It distinguishes between personnel costs (about 64% to 70% of dismantling costs of the BWR reference plant), costs for equipment, costs for articles of consumption, fees, external costs for all activities which are not taken on the decommissioning site and other costs. The decommissioning cost breakdown structure (CBS) organization of NIS-STILLKO is shown in Figure 2. In anology to the reference plant calculations for a typical BWR and PWR, the costs and cash flows of dismantling a specific plant are calculated regarding the individual situation of the facility, taking site-specific technical design aspects and assumptions for possible strategies and scenarios into account which correspond to the existing individual situation for (Petrasch/Luyten 2001):

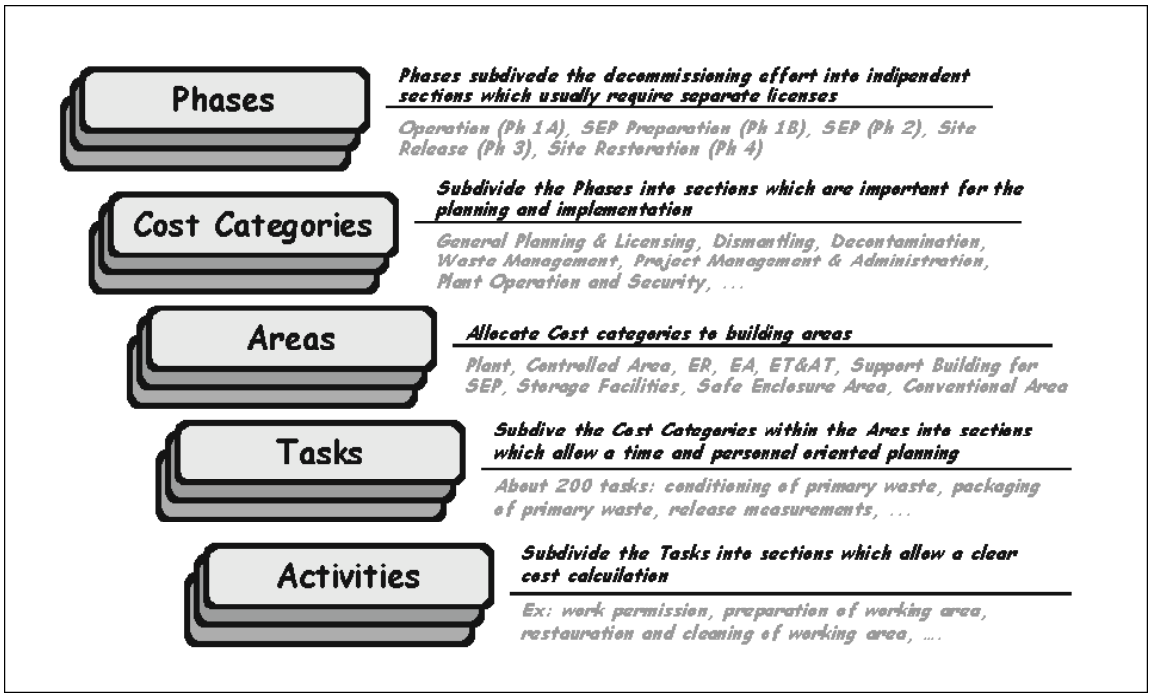
- Licensing requirements
- Waste management policy
- Company policy: personnel organization on site; capability of the personnel to use intended tools and devices
- Use of different technology and treatments
- Development of different decommissioning plans containing a list of decommissioning activities, description of the main technical items and a time schedule
- Decommissioning masses, numbers of waste containers, man-power requirements, and other aspects relevant for the size of costs

Figure 1: Schematic diagram of NIS software tool “STILLKO2” for the calculation of decommissioning costs and cash flows of commercial NPP in Germany



Source: www.nis-hanau.de (5 September 2006)

Figure 2: Decommissioning Cost Breakdown Structure (CBS) Organisation in the NIS-STILLKO software



Source: www.nis-ingenieure.de (15 March 2006)

- Other (general) boundary conditions like relevant international rules and regulations, maximum permissible radiation exposure of personnel, etc.

Since the NIS cost estimate only considers the complete nuclear site but not buildings which are free from contact with radioactivity (e.g., office buildings), costs of demolition of these buildings are not included in the decommissioning cost estimate.

Estimates of decommissioning costs of the different commercial NPP in Germany are not public. Therefore, Table 4 can just give a rough estimate of decommissioning costs for typical larger commercial BWR and PWR.

2.1.3 Calculation of decommissioning costs of nuclear facilities in East Germany following German unification

In East Germany, following German unification, all NPP were shut down by 1990. Energiewerke Nord GmbH (EWN), a company 100% owned by the German state since 1 January 2000, is responsible for the decommissioning activities which are planned to end in 2010.

Table 2: Actual and expected decommissioning costs of KGR and KKR in East Germany (million Euro)

Cost item	KGR [million Euro]	KKR [million Euro]	Total [million Euro]
Overhead 1990 – 1992	?	?	ca. 497
Mainly post-operation phase, but also contributions (advance payment) to final disposal	?	?	ca. 1,114
1993 – 1995: Decommissioning license; preparation of decommissioning 1993 – 2010: Changes in equipment; construction of interim storage facility ZLN	388	53	441
Dismantling of control area 1993 – 2010	211	121	333
Dismantling of monitored area 1993 - 2012	198	44	242
Management of remaining radioactive products 1993 - 2012	162	66	
Operation of interim storage 1995 – 2012	16		243
Waste management KBS 1993 - 2006	132	14	
Operation of interim storage 1995 – 2012	8		154
Management of waste from operation; Project nuclear control area 1993 - 2012	68	28	
Operation of interim storage 1995 – 2012	1		97
Site restoration 1991 – 1995 and 2010 - 2012	28	1	29
Qualification programmes for employees			4
Site development	47		47
TOTAL	**?**	**?**	**ca. 3,200**

Source: EWN GmbH (26 June 2006)

Financing is directly provided by the Federal Government. Based on their experiences with decommissioning in East Germany, EWN is now active in this field for other nuclear installations, too (e.g., for the WAK in Karlsruhe, for the AVR in Jülich, and in Russia).

Costs of decommissioning of the NPP in Rheinsberg and the five NPP in Greifswald which had been in operation in East Germany, as well as demolition costs of a further NPP in Greifswald which had never reached criticality, are shown in Table 2. It has to be noted that a detailed cost accounting was not installed before 1993; therefore, costs for the period 1990 to 1992 are just rough figures. Total decommissioning costs of these plants are expected to sum up to 3.2 billion Euro, of which about 2.2 billion Euro have been already used (Information by Ministry of Finance, 7 June 2006). About 40 to 60 employees regularly participate in planning and calculation of the different decommissioning activities.

The strategy for decommissioning of these plants was immediate dismantling in order to carry out the activities with own personnel as far as possible. Today, EWN still employs nearly 1,000 persons. However, in peak working times, up to 15,000 people from EWN and contractors were working on the sites. One advantage of the consequences of German unification was the possibility to use the existing personnel for several reactors at the same time (avoidance of buffer time), and to have some economies of scale and learning effects.

The Ministry of Finance (BMF) controls the decommissioning costs of these NPP. Since the ministry was not fully satisfied with the NIS cost model, complex business-oriented instruments to govern/control decommissioning expenditures have been installed which seem to be more sophisticated than the NIS cost model and which have put some pressure on EWN to reduce costs. Cost controlling usually works as follows:

- An external consultant reviews the technical developments during decommissioning.
- On this basis, benchmarks for specific decommissioning processes are set. Actually achieved and planned figures are regularly compared with each other.
- Every two to three years, planned total costs are re-calculated based on actual cost developments.

The experience shows that while there are shifts in costs between cost items, the total sum of estimated costs of 3.2 billion Euro has hardly changed for several years.

2.1.4 Calculation of decommissioning costs of other nuclear facilities

Information about decommissioning cost calculations for other commercial nuclear facilities (URENCO, ANF) are not accessible.

The NIS cost model is not only used for the commercial NPP but for many research reactors, too. However, for research facilities in operation, it seems that decommissioning costs have hardly been calculated yet. In contrast to the Ministry of Finance (BMF), the Federal Ministry for Research (BMBF) and the state (“Länder”) ministries seem to

have only weak cost controlling instruments for the nuclear facilities they are responsible for. However, they claim that they would control costs and would try to achieve cost reductions as far as possible.

2.1.5 Examples of decommissioning cost calculations / decommissioning costs occured

2.1.5.1 KKN, Niederaichbach

The first complete dismantling of a NPP in Europe, to a "green field", was carried out by NIS in Niederaichbach (KKN). Since August 1995, the only reminders of the nuclear power station in the green field are a memorial stone and a newly planted oak tree. A problem of this dismantling was, that although the heavy water moderated, gas cooled experimental reactor with 100 MW electrical capacity was only in service for two years, extensive measures were necessary for its removal. The decommissioning of KKN followed a three-phase plan:

- The removal of all transportable radioactive parts and materials like, for example fuel elements, operational waste and coolant.
- Safe enclosure period of all the radioactive areas, in the case of KKN for 11 years.
- Complete removal of all internal fittings and buildings back to a "green meadow".

In total 81,000 Mg of steel and concrete were removed. Only 5% of this was at least radioactive waste (after release measurements) and was packed into waste barrels and containers for storage at a final repository. Part of this waste is still being kept in interim storage at the research centre in Karlsruhe.

Costs of dismantling, decontamination, demolition and management and disposal of waste from dismantling amounted to about 150 million Euro in total, of which about 8 million Euro were paid by Siemens AG, the remaining, major part by the German government. Out of the 150 million Euro, about 108 million Euro were personnel costs of the contractor, 18 million Euro were costs of management and disposal of waste from dismantling, 15 million Euro were costs of preparation and operation of the safe enclosure, and 5.5 million Euro were costs of expertise and licenses (Thierfeldt 2000, 47; Bundesregierung 1995). Costs of spent fuel and further radioactive waste management during operation are not included in these figures.

2.1.5.2 KWW, Würgassen

According to information by E.ON, for the NPP in Würgassen (KWW), it seems that the 700 million Euro provisions accumulated for dismantling, decontamination, demolition and management of waste from dismantling will probably be more or less sufficient in the end to cover these costs (Landesregierung 2006a, DIW/WI/IAT 2004). Costs of spent fuel and further radioactive waste management during operation are not yet included in this figure.

2.1.5.3 Uranium mine, Wismut

Since its foundation in 1991, the Wismut GmbH, a federal government-owned company with about 2,300 employees, has been responsible for the decommissioning, cleanup and rehabilitation of uranium ore mining legacies in Saxony and Thuringia, which started already in 1990 by its predecessors. The main part of the work is expected to be completed by 2015. Until today, about 97 to 98% of the underground parts of the mining sites, and 63% of the uranium mining areas have been rehabilitated. Two examples illustrate the work done in the Wismut project: the municipality of Schlema has successfully restored its former glory as a spa town, and the municipality of Ronneburg will host the national horticultural exhibition in 2007.

Total decommissioning, cleanup and rehabilitation costs are expected to sum up to 6.2 billion Euro, of which 4.6 billion Euro occurred already until 2005, 0.8 billion Euro are estimated for 2006 – 2010, and further 0.8 billion Euro are estimated for the years 2011 and the following.

One consequential cost item is not included in the 6.2 billion Euro mentioned above: In 2004, the German Federal Social Court decided that a compensation of cancer other than lung cancer is justified for former Wismut uranium miners. The Court found that the larynx cancer developed by the miners must be seen as caused by their former occupation and therefore has to be compensated by the employers' liability insurance. The court decisions are relevant for approx. 2,000 other former Wismut miners who have contracted cancers other than lung cancer.

2.1.5.4 THTR-300, Hamm-Uentrop

The prototype Thorium-High-Temperature-Reactor (THTR 300) in Hamm-Uentrop was shutdown in 1989 after more than 16,000 hours in operation only, after the decision of its public shareholders not to further finance the plant's operation. The plant has been in safe enclosure condition since February 1997. Dismantling is expected to take place after about 30 years of safe enclosure, "provided respective funds are available" (Dietrich/Neumann/Röhl 1997).

In 1997, net total decommissioning costs for the period 1990 – 2009 were estimated at about 383 million Euro, including revenues from selling equipment, and including waste management and fuel transport and storage costs. Actual cost estimates are slightly higher: Total costs for preparation and operation of safe enclosure and contributions to final disposal between 1989 and 2009 are estimated at 444 million Euro, of which 395 Mio. Euro have been accumulated until 2005. For the time beyond 2009, there is no cost estimate yet.

2.1.5.5 Research Centre, Karlsruhe

Karlsruhe Research Centre ("Forschungszentrum Karlsruhe") has already completed several larger decommissioning projects (Pfeifer 2004; Pfeifer et al. 2003; Pfeifer et al. 2004):

- KKN in Niederaichbach (cf. chapter 2.1.5.1)
- Research reactor HDR ("Heissdampfreaktor Grosswelzheim") (decommissioning completed in 1998)

Furthermore, the following facilities are in the process of decommissioning:

- Multi-purpose research reactor MZFR (cf. chapter 2.1.5.6)
- Karlsruhe reprocessing plant WAK (cf. chapter 2.1.5.7)
- Research reactor FR 2 (partly decommissioned by 1996; reactor building used as a museum; reactor block in safe enclosure)
- Prototype fast breeder reactor KNK II ("Kompakte natriumgekühlte Kernanlage") (decommissioning is planned to be completed by 2008).

Expected decommissioning costs for these facilities are listed in Table 3.

Table 3: Overview on decommissioning costs expected by BMBF for several nuclear facilities which are at least partly publicly-financed (State: April 2006)

Nuclear facility	Decommissioning period for which this calculation is valid	Expected decommissioning costs in this period [1,000 Euro]	Expenditures by Federal Government in this period [1,000 Euro]	Expenditures by Federal Government by 2005 [1,000 Euro]	Expected contributions by third parties (public or private organisations) [1,000 Euro]	Remark
WAK	(1991-2035)	2,230,091	1,136,546	411,040	*1,093,545*	*
KNK II	(1992-2010)	291,052	261,947	207,598	29,105	
MZFR	(1985-2010)	274,700	274,700	193,030	0	
THTR-300	(1997-2009)	*68,957*	*35,723*	*25,497*	*33,234*	**
AVR	(1987-2012)	*398,700*	*317,030*	*200,627*	*81,670*	***
FRJ-1	(1994-2007)	26,000	23,400	20,700	2,600	
FRJ-2	(2008 - ?)	100,000	90,000	0	10,000	
FR-2	(??)	55,000	49,500	0	5,500	
FRG 1+2	(2010 - ?)	100,000	90,000	0	10,000	
Total		**3,544,500**	**2,278,846**	**1,058,492**	**1,265,654**	

It should be noted that the expected costs given are only costs given by BMBF for the period given here. For three of the facilities listed, the following remarks have to be considered:

* Other contributions are mainly coming from the State of Baden-Württemberg; 500 million Euro have been contributed by German Society for the Reprocessing of Nuclear Fuels (DWK). Costs exceeding expected costs will be probably paid by the public.

** Safe enclosure between 1997 and 2009 only. For the period 1989 to 2009, 444 million Euro have to be calculated in total. For the time beyond 2009, there is neither a cost estimate nor a provision of funds. It has to be negotiated between the Federal government, the government of the state of North Rhine-Westphalia and the energy companies having a share in the facility who will pay for costs that will occur after 2009.

*** In total, decommissioning costs will be even higher and will sum up to about 515 million Euro, of which are about 215 million Euro for the safe enclosure, about 200 million Euro for dismantling, decontamination and demolition and about 100 million Euro for final disposal.

Source: BMBF; Landesregierung 2003; Landesregierung 2006; Pfeifer et al. 2003.

2.1.5.6 MZFR, Karlsruhe

Currently, the activated components of the MZFR are being dismantled remotely. The MZFR is the first pressurized water reactor in Germany that was moderated and cooled with heavy water. The further the dismantling work has proceeded, the more reliable is the cost estimate. Between 1994 and 2003, dismantling cost estimates increased by nearly 50%. According to (Pfeifer et al. 2004), 35% of this increase is probably due to price rise and 65% to adaptations needed to take into account of changed boundary conditions. Today, BMBF estimates costs of decommissioning activities in the period 1985 – 2010 at 275 million Euro, of which are about 190 million Euro costs of dismantling only, of which are about 81 million Euro related to the reactor pressure vessel (Pfeifer et al. 2004). Decommissioning of MZFR is expected to be completed by 2009/2010.

2.1.5.7 Karlsruhe reprocessing plant (WAK)

In 1991, the Karlsruhe reprocessing plant (WAK) was shut down after 20 years of operation. Decommissioning is expected to last until 2010. In 2006, the vitrification plant and the remaining HAWC storage facilities will be disassembled. The premises are envisaged to be recultivated by 2010 (for this and the following information cf. Pfeifer et al. 2003).

The plant was taken into operation in 1972. First, shareholders were coming from the chemical industry. Later, after responsibility for the construction and operation of a reprocessing plant had been taken over by the energy companies, the shareholder was the German Society for the Reprocessing of Nuclear Fuels (DWK) that had been founded by the energy companies.

The decision to shut down and dismantle the WAK was taken by the Federal Republic of Germany and the State of Baden-Württemberg. Both are shareholders of Karlsruhe Research Centre and of the DWK. The decision was taken after the energy companies, at the end of the 80ies, decided not to construct the reprocessing plant at Wackersdorf and not to take into operation the fast breeder reactor at Kalkar (SNR 300).

Moreover, it was decided that the Karlsruhe Research Centre as the operator of the plant should bear responsibility for the entire decommissioning project. The WAK BGmbH was encharged with the remaining operation as well as with the planning and execution of dismantling activities. Recently, the responsibilities for the remaining decommissioning activities were handed over to EWN GmbH. The Federal Ministry for Research has the hope that this will lead to a decrease in decommissioning costs.

According to figures by BMBF, total decommissioning costs expected for the period 1991 to 2035 sum up to more than 2.2 billion Euro.

2.1.5.8 ITU – Karlsruhe (JRC facilities)

To fulfil its various tasks, the Institute for Transuranium Elements (ITU) in Karlsruhe, a JRC facility financed by the European Commission, is provided with a large number of equipment and facilities (among others, are 24 hot cells).

Under the European Commission's JRC decommissioning programme, ITU in Karlsruhe handles the removal of waste accumulated at the time of past research work, and dismantles equipment that has become obsolete (for this and the following information cf. European Commission 2004). These activities are to be distinguished from the day-to-day management of the installations and of the waste generated by R&D activities, which is not financed by the European Commission's decommissioning programme but by its research programme.

There is no exact timetable for final dismantling of the ITU facilities yet, because dismantling is planned to start after the stoppage of the research programme, which has not yet been planned. Start of dismantling is not expected before 2015. The European Commission, in its own calculations, assumes the year 2025 (or even later). Until final dismantling starts, there are only the above-mentioned on-going smaller decommissioning activities.

The facilities final decommissioning activities will be subcontracted to external companies with experience in this sector. As it is the case for other licensees in Germany, the Commission as the operator of the facilities remains the owner of the waste, which it transfers to an external company. Therefore, although the Commission pays its financial contribution to final disposal already today, this does not free it from any uncertainty as to final disposal cost. Internal financial risks are tried to be minimised by the implementation of project management methods and tools, which are widely used in industry for the management of major projects.

Expenditures for the smaller on-going decommissioning activities in the period 1999 – 2003 amounted to 16 million Euro. In recent years, there have been different evaluations of expected total decommissioning costs, partly based on studies by external companies. While the JRC's 1998 evaluation based on two studies by external German and French consultants, estimated total decommissioning costs at 149 million Euro, the latest evaluation made in 2003 by a consortium of four companies arrived already at 367 million Euro (389 million Euro including the "green field" option; not including JRC's staff costs)(all figures in Euro 2003). The latter cost estimate was initiated by the Court of Auditors.

Table 4 Overview on decommissioning costs for a typical larger BWR and PWR in Germany (price level 2000)

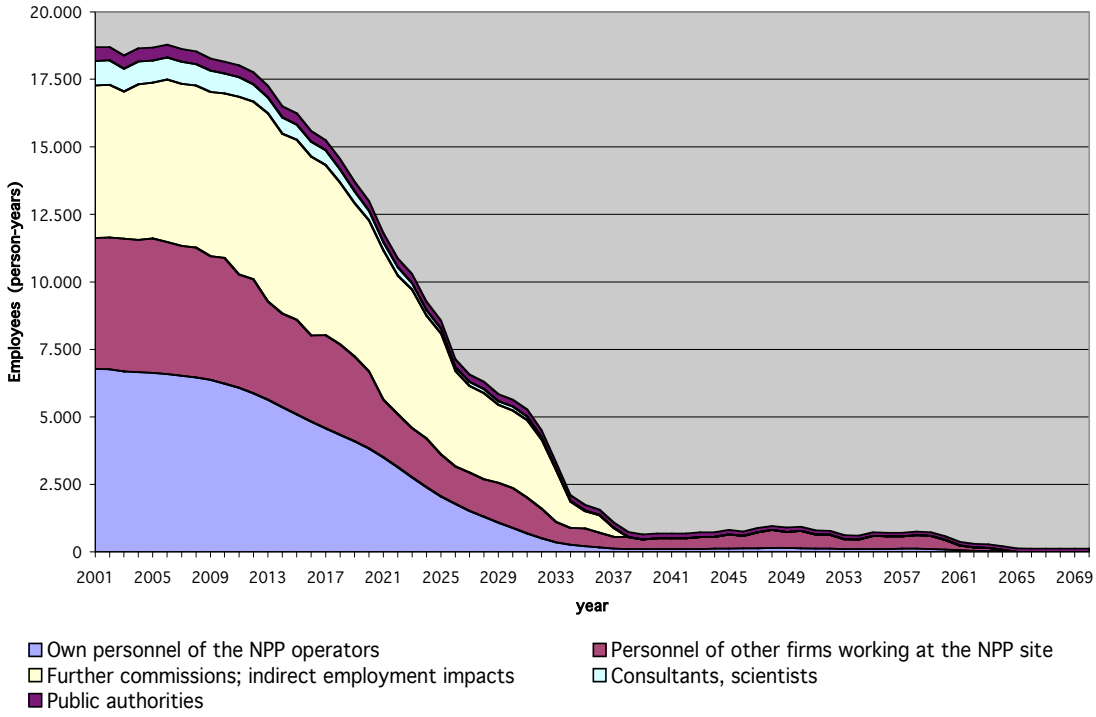
Decommissioning activity	**Years the activity took place / is expected to take place**	**Total decommissioning costs [Mio. Euro]**	**Annuity of decommissioning costs in relation to output over lifetime [ct/kWh; 4%]**	**Remarks**
Facility shutdown and pre-decommissioning activities		250		Rough rule of thumb by E.ON
Safe enclosure		0		Direct dismantling assumed
Dismantling (nuclear) and decontamination activities		305 - 400 (PWR) 330 – 500 (BWR)		Lower value by NIS (reference plants/model calculation), higher value according to rough rule of thumb by E.ON
Demolition of non-radioactive parts (conventional dismantling)				
Processing, storage and disposal of radioactive waste from dismantling		350		Rough rule of thumb by E.ON
Spent fuel management (interim storage, reprocessing, waste solidification, storage processed waste streams and disposal of high level waste or spent fuel as such covering the whole lifetime of the NPP)		*> 1,000 (1.000 – 2.500)*		To a large extent, these costs are variable costs depending on the kWh generated (i. e., depending on the lifetime and the efficiency of the plant) and the spent fuel and waste management strategy chosen. Therefore, the total sum of these costs can vary very much. Furthermore, these costs are subject to large uncertainties, because costs of final disposal are not known today.
Management of other radioactive waste from operation of the NPP (processing, storage and disposal of low and intermediate level waste from operation) covering the whole llifetime of the NPP				
Site restoration, cleanup and landscape		?		Not known.
Supporting programmes for employees		?		Not known. In past years, public support programmes could be used to reduce these costs. However, these possibilities have been partly diminished in recent years.
Supporting programmes for regional development		?		Not known. Only few local governments have set aside part of local tax income from operation of the plant for the time after the shut down.
TOTAL		***> 2,000 (2,000 – 3,500)***		

Source: Own very rough estimate based on oral information by E.ON and WI/ÖI 2000, Mertin/Hortmann 2001, and Petrasch/Luyten 2001.

2.2 Future decommissioning strategies and cost developments

As in the past, the operators' decisions on the decommissioning strategy for a specific nuclear facility will take several aspects into account, but will mainly aim at reducing decommissioning costs and limiting financial risks. It can be expected, that after the German government has started the process of identifying a deep repository site, and particularly after the choice of a final disposal site has been made, decommissioning strategies for commercial NPP will tend to be immediate dismantling, or mixed strategies which try to optimise personnel and financial resources.

Figure 3: Rough estimate of the development of jobs in the context of decommissioning of those 19 NPPs in Germany, which were in operation in the year 2001, plus the NPPs at Würgassen and Mülheim-Kärlich (own personnel of the NPP operators, personnel of other firms, indirect employment effects) (direct dismantling assumed)



Remark: Jobs related to the construction and operation of a repository for final disposal of radioactive waste, to export of nuclear technology, and to other nuclear facilities are not included in this estimate. This estimate only includes the development of jobs related to the 21 NPPs mentioned above. In total, there were about 23,250 to 30,000 person-years of work secured by nuclear activities in Germany in the year 2001, of which about 19,000 were within the field of operation and decommissioning of these 21 NPPs.

Source: Irrek, 2005.

Plant- or site-specific information on cost estimates for future decommissioning of privately-owned nuclear facilities is not accessible. Therefore, Table 5 only lists decommissioning cost estimates for publicly-owned facilities or for facilities already decommissioned or in the process of decommissioning.

Figure 3 shows the expected development of jobs in the context of decommissioning of the 19 NPPs in Germany, which were in operation in the year 2001, plus the NPPs at Würgassen and Mülheim-Kärlich (own personnel of the NPP operators, personnel of other firms, indirect employment effects). Immediate dismantling is assumed here. In total, there were about 23,250 to 30,000 person-years of work secured by nuclear activities in Germany in the year 2001, of which about 19,000 were within the field of operation and decommissioning of these 21 NPPs (DIW/WI/IAT 2004). Compared to the job curve in Figure 3, total expenditures for the remaining operation, dismantling, decontamination and demolition of these 21 commercial NPPs are expected to show a similar run, because personnel costs are a main part of operation and decommissioning expenditures. Jobs/expenditures related to the construction and operation of a repository for final disposal of radioactive waste, to export of nuclear technology, and to other nuclear facilities are not included in this curve and have to be added.

Table 5 Expected total costs of future decommissioning of nuclear installations in Germany (Price level 2004)

Short name of nuclear facility	**Kind of facility: NPP = nuclear power plant RR = Research reactors Others: please specify**	**Years decommissioning activities are expected to take place**	**Total decommissioning costs estimated [Mio. Euro]**	**Annuity of estimated decommissioning costs in relation to output over lifetime [ct/kWh for NPP; 4%]**	**Remarks**
GKN 1	NPP	> 2009	Information on site-specific cost estimates is not accessible		As a very rough rule of thumb, it can be assumed that 1 billion Euro is needed for dismantling etc. of a PWR and 1.1 billion Euro for a BWR respectively (in practice, cost estimates for dismantling are based on NIS cost model; this rough estimate has been provided by E.ON). Furthermore, more than 1 billion Euro (1 to 2.5 billion Euro) have to be calculated for waste management and disposal, if all cost items are included. However, the detailed cost estimate depends very much on the plant-specific equipment, buildings, decommissioning strategy, lifetime and efficiency of the plant, final disposal and waste management concept, process of identifying a suitable site for final disposal, etc., and can deviate from this amount. Information on site-specific cost estimates is not available. Immediate dismantling is assumed here for the years decommissioning activities are expected to take place. Years given here are expected years of shutdown according to own calculations by Wuppertal Institute.
GKN 2	NPP	> 2022			
KKP 1	NPP	> 2012			
KKP 2	NPP	> 2019			
KKG	NPP	> 2014			
KRB-B	NPP	> 2021			
KRB-C	NPP	> 2024			
KKI 1	NPP	> 2012			
KKI 2	NPP	> 2019			
KWB A	NPP	> 2007/2008			
KWB B	NPP	> 2014			
KKE	NPP	> 2025			
KWG	NPP	> 2018			
KKU	NPP	> 2012			
KBR	NPP	> 2019			
KKB	NPP	> 2010			
KKK	NPP	> 2016/2017			
KWO	NPP	> 2005		(> 0,45)	Year given here is year of shutdown. Closure in accordance with nuclear phase-out agreement. Estimated specific decommissioning costs per kWh do not take into account spent fuel costs and other waste management costs from operation. They are based on discounted provisions accumulated until 31/12/2003.

KKS	NPP	> 2003 - 2015		(> 0,37)	First year given here is year of shutdown. Closure because of economic considerations. Estimated specific decommissioning costs per kWh do not take into account spent fuel costs and other waste management costs from operation. They are based on discounted provisions accumulated until 31/12/2003.
KMK	NPP	2003 - 2013			Plant was already shut down in 1988. Closure in accordance with nuclear phase-out agreement and following an early shutdown.
KWW	NPP	1997 - 2017	(> 700)	(> 0,41)	Dismantling, decontamination, demolition and management and disposal of waste from dismantling only. Closure because of economic considerations. Estimated specific decommissioning costs per kWh do not take into account spent fuel costs and other waste management costs from operation. They are based on discounted rough information given by E.ON Kernkraft GmbH on total decommissioning costs.
KKR	NPP	< 2012	3,200		Early closure in the course of German unification. It should be noted that there was also a sixth reactor built which never came into operation but had to be demolished, too.
KGR 1	NPP				
KGR 2	NPP				
KGR 3	NPP				
KGR 4	NPP				
KGR 5	NPP				
AVR	NPP	1987 – 2012	ca. 515		Of which are about 215 million Euro for the safe enclosure, about 200 million Euro for dismantling, decontamination and demolition and about 100 million Euro for final disposal. 70% of the costs are paid by the Federal Government, 30% by the government of the state of North Rhine-Westphalia.
KKN	NPP	< 1995	150		Dismantling, decontamination and demolition only
THTR-300	NPP	1997 – ?	>444		These are costs for preparation and operation of safe enclosure between 1989 and 2009 only, of which 395 Mio. Euro have been accumulated until 2005. For the time beyond 2009, there is neither a cost estimate nor a provision of funds. It has to be negotiated between the Federal government, the government of the state of North Rhine-Westphalia and the energy companies having a share in the facility who will pay for costs that will occur after 2009.
MZFR	NPP	1985 – 2010	275		Of which are about 190 million Euro estimated dismantling costs.
KNK-II	NPP	1992- 2010	291		Dismantling, decontamination and demolition only

FRM-II	RR	Not decided yet	Not calculated yet		The responsible state ministry of Bavaria has not considered to develop a decommissioning plan or cost estimate yet. The reactor has started operation in 2005
FRJ-1	RR	1994 – 2007	26		Dismantling, decontamination and demolition only
FRJ-2	RR	2008 - ?	100		Dismantling, decontamination and demolition only
FRG-1	RR	2010 - ?	100		Dismantling, decontamination and demolition only
FRG-2	RR				
FR-2	RR	?	55		Dismantling, decontamination and demolition only
URENCO	Enrichment	Information not accessible	Information not accessible		Not any information accessible.
ANF	Fuel fabrication	Information not accessible	Information not accessible		Not any information accessible.
WAK	Reprocessing, complex site	1991 - 2035	2.230		
ITU-JRC	Research facilities	< 2030	389		European Commission JRC research facilities. Decommissioning activities have to be distinguished from the day-to-day management of the installations and of the waste generated by R&D activities underway, which is financed by the research programme.
Wismut	Uranium mine	87.1% until 2010	6.200		Until 2005: 4.6 billion Euro; 2006 – 2010: 0.8 billion Euro; > 2010: 0.8 billion Euro

Source: BMBF; BMF; EWN GmbH; European Commission (2004); ; Landesregierung 2003; Landesregierung 2006; Pfeifer et al. 2003; Pfeifer et al. 2004; Pfeifer 2004; oral information by E.ON and Bayerisches Staatsministerium für Wissenschaft, Forschung und Kunst; internet pages of operators; own calculation of expected lifetime of operating commercial NPP based on BfS data.

3 Funds and fund management

3.1 Setting aside funds

3.1.1 Overview on methodologies in place

The way funds are set aside for financing decommissioning activities differs between purely publicly-owned nuclear installations, nuclear installations with mixed ownership, and nuclear installations belonging to private companies (nuclear power plants, fuel cycle facilities, etc.):

- In general, decommissioning of purely publicly owned nuclear facilities is financed from the current budget. There are no provisions made for future payments. For most projects, the Federal Government covers the bulk of the costs. For some projects, part of the costs is covered by the State Governments ("Länder"). Furthermore, there are the ITU European Commission JRC research facilities in Karlsruhe, financed from the current budget of the European Union.
- For facilities with mixed ownership, there are special arrangements needed to clarify how much of the costs have to be born by the public and how much by the private organisations.
- The private owners of (shares in) nuclear facilities (these private owners are either limited companies: "GmbH", or public stock companies: "AG") build up internal unrestricted funds according to German commercial law (HGB; in addition, AktG has to be taken into account by public stock companies) based on their liabilities according to section 7, 9 and 9a of the Atomic Energy Act (AtG), statutory ordinances promulgated on the basis of the AtG, as well as general administrative provisions. On the corporate group ("Konzern") level, international accounting standards are applied (IAS/IFRS; US-GAAP).

3.1.2 Publicly-owned facilities

As a general rule for all publicly-owned nuclear facilities owned by the Federal or state governments, it can be stated that there are no ex-ante limits or restrictions with regard to the decommissioning budgets provided. The ministries partly justify this by the fact, that final disposal costs are not known today because a repository has not been identified yet. Furthermore, all costs, which occur to achieve a secure decommissioning, would have to be born by the public anyway. However, according to the Financial Times (6 February 2006), the German Federal Court of Auditors has critised this unlimited payment of decommissioning costs by the state, and the respective budget increases, which occurred in the past due to the fact that actual decommissioning costs often exceeded planned ones.

Budgeting for decommissioning costs of the JRC facilities works as follows: On the basis of the decommissioning programme presented by the Commission in 1999, the

Council and the Parliament approved the creation of a separate budget heading (B4-3400). Since 2001, there have been direct appropriations during the budget procedure. However, since estimated cost not always equal real actual cost, an additional allocation at the end of the financial year is partly needed. At the same time, the JRC's own staff costs are charged to Euratom's research framework programme (budget heading B6-12).

3.1.3 Facilities with mixed ownership

In the following, the special financing arrangements for three nuclear facilities with mixed ownership are explained in more detail:

- For decommissioning of KKN in Niederaichbach, Siemens provided about 8 million out of about 150 million Euro decommissioning costs.
- To finance decommissioning activities of Karlsruhe reprocessing plant (WAK), the Federal Republic of Germany/State of Baden-Württemberg and the DWK paid 500 million Euro each into a decommissioning fund. Although cost estimates increased over time and now exceed 2.2 billion Euro, liabilities of the private shareholders of WAK had been limited, i.e. that cost overruns have to be born by the public.
- Between 1989 and 2005, the Federal government covered 28.9% of decommissioning costs of THTR-300 in Hamm-Uentrop, the state of North Rhine-Westphalia 33.7%, the operator Hochtemperatur-Kernkraftwerk GmbH (HKG GmbH) 35.1% and other energy companies 2.4%. For the time beyond 2009, there is neither any cost estimate yet nor any provision of funds. It has to be negotiated between the Federal government, the government of the state of North Rhine-Westphalia and HKG GmbH who will pay for costs that will occur after 2009. Until today, already several rounds of negotiations between the shareholders took place in order to decide on the shares in decommissioning costs to be born by each of them. Several energy companies are shareholders of HKG GMBH:
  - RWE Power AG (31%)
  - Gemeinschaftskraftwerk Weser GmbH & Co. OHG (26%)
  - Mark E AG (26%)
  - Gemeinschaftskraftwerk Hattingen GmbH (Stadtwerke Wuppertal AG, RWE Power AG) (12%)
  - Stadtwerke Aachen AG (5%).

3.1.4 Provisions by private companies liable for (part of) decommissioning of a nuclear facility

On the corporate group level, E.ON set up provisions according to US-GAAP, EnBW, RWE and Vattenfall follow IAS/IFRS. Since the IAS/IFRS accounting standard is already explained in another report of this project (covering Work Package 2 of this project), the following description concentrates on the methodology for setting up provi-

sions according to the German commercial code (HGB) and according to German tax law. Differences between IAS/IFRS, US-GAAP, HGB and German tax law principles are well-explained by (Bug 2005) and (Epstein/Mirza 2006). The main principle differences in the valuation of provisions between IAS/IFRS, US-GAAP and HGB are listed in Table 6.

Table 6: Main principle differences in setting up provisions between US-GAAP, IFRS and HGB

US-GAAP	IFRS	HGB
Provisions are set up considering the lower bound of the available estimates of the amount needed in the future to cover the liabilities. Estimated future price levels taken into account. Sometimes provisions are discounted values, sometimes not.	Provisions are set up considering the best-available estimate of the amount needed in the future to cover the liabilities. Estimated future price levels taken into account. If discounting has a considerable impact, provisions will have to be discounted values. Discounting periods can differ between cost items, and follow the technical decommissioning timetables.	For some kind of liabilities, provisions have to be made, for others they can be made. Setting up provisions will only be allowed if the liabilities can be sufficiently concretised. Foreseeable risks and losses shall be taken into account. The amounts to be provided have to be reasonable by conservative commercial judgement according to the principle of prudence. It is not needed to provide for the full amount from the beginning of operation. Provisions can be accumulated over some time. Assets and liabilities have to be individually valued according to price levels at balance sheet day. Discounting will only be allowed if part of the liabilities contain interest.

Source: Epstein/Mirza 2006, 1256; Bug 2005.

The obligation to set up provisions (internal, unrestricted decommissioning funds) starts with the beginning of operation, but not the complete amount is required at this time. According to German tax law, decommissioning provisions for nuclear reactors in German tax balance sheets have to be set up as follows:

- Provisions for spent fuel management are allocated according to their burn-up over the period they are used in the reactor (about 4-5 years). Discounting takes place in a layered procedure over five years, which probably means that the time the spent fuel is placed in the spent fuel storage bay will be added to the burn-up period (i.e. over 9 - 10 years in total).
- Provisions for the management of the core are allocated over the first 19 years of operation (the change in German tax law in 1999/2000/2002 did not affect the length of this allocation period).
- As long as the final shut down of a nuclear facility is not exactly determined, provisions for dismantling, decontamination and demolition have to be accumulated in equal instalments over the first 25 years of operation (19 years before 1999).
- Since 1999, provisions for additional costs of manufacturing Mixed Oxide Fuel (MOX) are not allowed anymore, as well as any additional costs with regard to the

management of remaining fissile materials in case they are not used for MOX production.

- Provisions for management of radioactive waste from operation are made according to the waste generated.
- Claims of future interest on advance payments for a final disposal site have to be balanced with the liability which says that operators have to contribute to financing costs of a final disposal site.
- Since 1999, provisions for nuclear decommissioning have to be discounted by a nominal discount rate of 5.5%. However, the discounting period is limited to the period during which the provisions are accumulated (see above). In contrast to IAS/IFRS, the discounting period does not cover the whole time between generation of the kWh which causes the liability and start of the respective decommissioning activity.
- For changes in the size of decommissioning provisions caused by the new German tax law in 1999, a ten years transition period has been granted.

It can be assumed that other nuclear installations are treated similarly.

The respective cost estimates on which the provisions are based are regularly checked by the fiscal authorities of the state ("Länder") ministries. However, the possibilities by the fiscal auditors to really control the economic and technical basis for the values determined are limited. Nevertheless, values accepted by them are usually also accepted by the price regulators of the state ("Länder") ministries (in Germany, price regulation still exists; there is even a discussion to extent it beyond June 2007). The possibilities for the energy companies to influence this tax balance sheet position have always been large and extensively used. For example, on the basis of cost estimates according to the NIS cost model for dismantling, individual risk premiums of, for example, 10% have been added. Recently, due to the liberalisation process, balance sheet influencing measures start to differ between the four large energy companies.

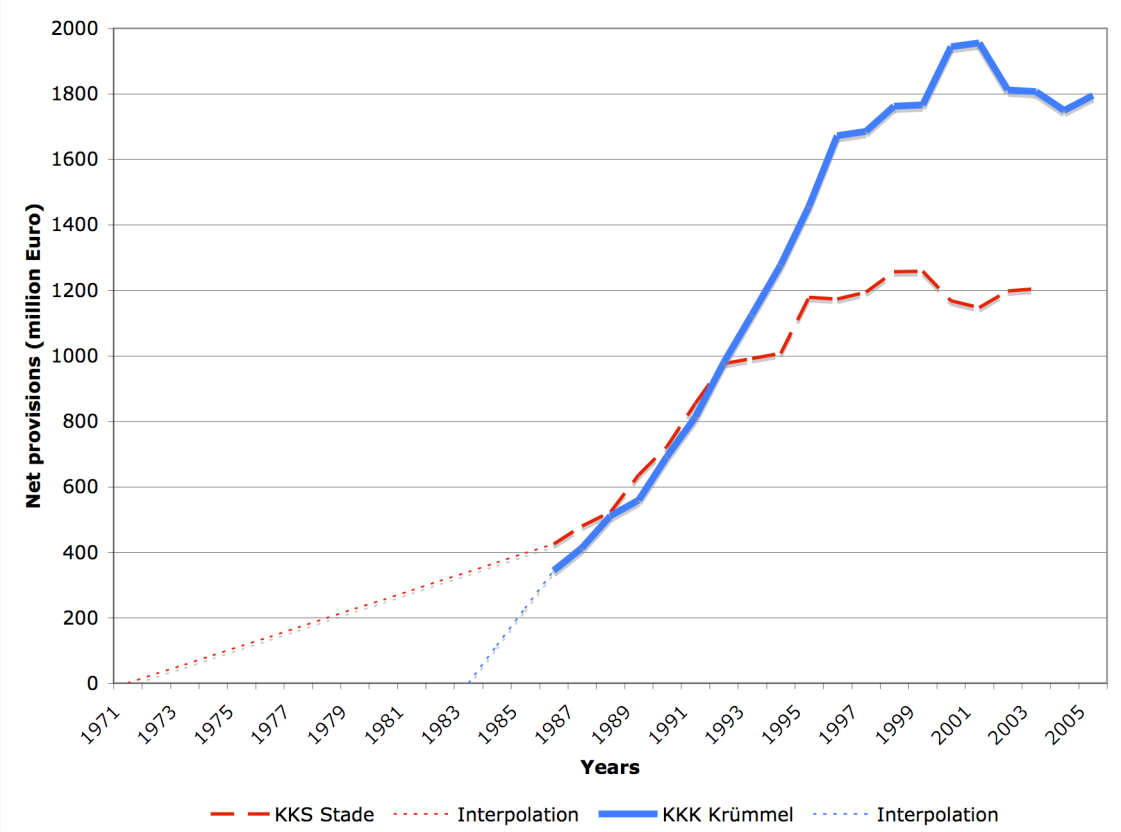
According to German commercial code (HGB), under specific circumstances, the valuation method used in the commercial balance sheet has to follow that used in the tax balance sheet ("umgekehrtes Maßgeblichkeitsprinzip"). This is particularly the case if a specific valuation method is mandatory in the tax balance sheet, but some freedom of choice exist in the commercial balance sheet. Therefore, even after the implementation of the new German tax law of 1999/2000/2002, provisions set up for decommissioning liabilities in German tax balance sheet should not differ much from those made in German commercial balance sheets, at least for the years until 2001. However, for the years 2002 and the following, although an agreement has been reached between energy companies and the German Federal Ministry of Finance on how to interpret German tax law with regard to the decommissioning provision, this agreement is not shared by all state ("Länder") governments. Therefore, for the year 2002 and the following, some differences might still occur.

In the long run, it can be expected, that German commercial codes will more and more follow international accounting standards. This might further trigger the discussion

about German tax law and the possibilities to bring German tax balance sheets and commercial balance sheet principles in line with each other.

While the role of the fiscal auditors has been mentioned already, the role of the certified auditors of the commercial balance sheets has not been described yet. They have the same difficulties in effectively controlling the values set. However, due to a tightening of legal rules and responsibilities set for certified public accountants/auditors in recent years, due to legal requirements with regard to financial risk management, and following problems with provisions for other long-term liabilities (e. g., pension funds) in other countries, there interest in the financial risks involved in the current scheme of setting up provisions for nuclear decommissioning is increasing. On the other hand, they avoid any trouble during auditing that could end in loosing their client as long as this will be in accordance with the law.

Figure 4: Net provisions accumulated by two commercial NPP operators in Germany at the level of a limited company ("GmbH") operating only one NPP each (Krümmel: 1,316 MW gross; Stade: 672 MW gross)



Source: Annual reports / commercial balance sheets of KKW Krümmel GmbH & Co. oHG and KKW Stade GmbH. It should be noted that the dotted lines are just interpolations by Wuppertal Institute. Stade was finally shut down in 2003.

How provisions have been accumulated at the level of a limited company ("GmbH") operating one NPP only, can be seen in While the role of the fiscal auditors has been mentioned already, the role of the certified auditors of the commercial balance sheets has not been described yet. They have the same difficulties in effectively controlling the

values set. However, due to a tightening of legal rules and responsibilities set for certified public accountants/auditors in recent years, due to legal requirements with regard to financial risk management, and following problems with provisions for other long-term liabilities (e. g., pension funds) in other countries, there interest in the financial risks involved in the current scheme of setting up provisions for nuclear decommissioning is increasing. On the other hand, they avoid any trouble during auditing that could end in loosing their client as long as this will be in accordance with the law.

Figure 4. The curves show net provisions, i.e. that advance decommissioning payments are already deducted from gross provisions. It should be noted that provisions do not only increase with years of operation but also due to increases in cost estimates/prices for decommissioning activities. Cost estimates increased during the 1990ies, because then first experiences with decommissioning could be taken into account and original planning figures were too optimistic. The decrease in net provisions of KKK (Kernkraftwerk Krümmel GmbH) after 1999 is probably due to the German tax reform 1999/2000/2002.

3.2 Management of funds

In the year 2005, net provisions for future decommissioning shown in the commercial balance sheets of the main shareholders of commercial nuclear facilities (NPP, fuel fabrication, enrichment) in Germany sum up to about 30 billion Euro.

In general, it is not questioned at all by anybody, that the provisions for future nuclear decommissioning are a major source of internal finance at zero cost for the operators of commercial nuclear facilities in Germany and their mother companies (cf., e.g., Kroll 1990). One indicator for this is that the four large energy companies have been hardly dependent on bank loans.

The large energy companies claim that they invest the financial equivalent of the nuclear provisions into assets matching maturities of the respective nuclear liabilities, so that the money will be available as soon as it will be needed to cover decommissioning expenditures. However, a direct link from provisions / liabilities made on the right side of the balance sheet to assets on the left side of the balance sheet cannot be drawn. The companies further claim that they would have to carry out a prudent investment policy due to the general accounting principle of German commercial law, which would be controlled by their auditors. Therefore, investment and financial planning as well as financial risk management would be thoroughly carried out. Otherwise, they could be prosecuted for uncareful commercial behaviour. However, while there is a general accounting principle in the German commercial code that requires to value the different items in a balance sheet prudently, and while concealment or wrong description of the financial situation of a company can be prosecuted according to §331 of the German commercial code (HGB), there are not any specific (legal) requirements with regard to the investment policy of the companies.

In the following, some examples are presented which depict the typical flow of money from a licensee who is a limited company (“GmbH”) being responsible for one NPP

only to its mother company and to investments made by the (mother company of the) mother company at the corporate group or public stock company level:

- The limited company sets up the provisions.
- It then includes the respective costs into its power price calculations so that the turnover covers, among others, decommissioning costs (as far as the liberalised market allows this).
- The cash flow is then used, e.g., to invest in bonds, to lend it to the mother company, or for other kind of investment. Loans to the mother company are often at a very low or even zero interest rate as it has been the case in KWG Grohnde in the 1990ies (cf. the example in Irrek 1996, 22).
- On the level of the mother company of such a limited company (which is, again, a limited company with mother companies within the same corporate group, or a public stock company or corporate group level), nuclear provisions are usually not internally segregated. Specific investment restrictions do not exist. This is in contrast to pension funds of some of the corporate groups with nuclear facilities in Germany.

Table 7 and Table 8 show respective balance sheet examples of a typical limited company (Kernkraftwerk Krümmel GmbH & Co. oHG) and of a corporate group (E.ON). 50% of the shares in Kernkraftwerk Krümmel GmbH & Co. oHG are held by E.ON Kernkraft GmbH which belongs to E.ON AG / E.ON corporate group.

Table 7: Typical balance sheet of a limited company ("GmbH": Kernkraftwerk Krümmel GmbH & Co. oHG) operating only one or two commercial NPP (Year 2005) (million Euro)

Assets	[1,000 Euro]	**Liabilities / Equity**	[1,000 Euro]
Fixed assets		**Shareholders' equity**	
Intangible assets	606	Vattenfall Europe Nuclear Energy GmbH	51,130
Property, plant, equipment	116,850	E.ON Kernkraft GmbH	51,130
Nuclear fuel	72,071	**Net provisions for nuclear decommissioning**	1,795,407
Current assets		Other provisions	19,494
Inventories	1,575	**Liabilities**	39,530
Accounts receivable from shareholders and from trading with shareholders	777,760		
Accounts receivable from trading with third parties	30,219		
Other assets (mainly time deposit)	857,500		
Checks / cash	100,044		
Deferred charges and prepaid expenses	66		
Total	**1,956,691**	**Total**	**1,956,691**

Source: Annual report / commercial balance sheet of Kernkraftwerk Krümmel GmbH & Co. oHG, 2005.

Table 8: Typical balance sheet of a corporate group ("Konzern": E.ON Konzern) to which several commercial NPP belong (Year 2005) (million Euro)

Assets	[million Euro]	**Liabilities / Equity**	[million Euro]
Fixed assets		**Shareholders' equity**	44,484
Goodwill	15,363	Other shares	4,734
Other intangible assets	4,125	**Net provisions for nuclear decommissioning:**	13,362
Property, plant, equipment	41,323	*spent fuel management*	*5,003*
Financial assets	21,686	*dismantling / demolition*	*8,803*
Current assets		*waste management*	*425*
Inventories	2,457	*advance payments*	*./. 869*
Financial accounts receivable and other assets	2,019	**Other provisions**	20,500
Operational accounts receivable and other assets	21,354	**Liabilities**	33,414
Checks, cash, etc.	15,119	**Deferred charges, etc.**	10,068
Other current assets	681		
Deferred charges/taxes and prepaid expenses	2,435		
Total	**126,562**	**Total**	**126,562**

Source: Annual report / commercial balance sheet of E.ON corporate group, 2005.

3.3 Special cases: Fall-back option and transfer of ownership

The example of the THTR-300 in Hamm-Uentrop shows the financing problem of a plant with mixed ownership which had been shut down after only more than 16,000 hours of operation. Decommissioning financing for the years beyond 2009 has not been clarified or provided yet. Of course, such a case will hardly happen if there is an early shut down of a purely privately owned facility which belongs to a large corporate groups as long as the corporate groups feels responsible for the liabilities of the plant.

However, it has to be questioned if the contractual arrangements / letters of comfort between a limited company being responsible for one or two NPP only and its mother company will be rigorous enough to cover all contingencies, particularly in case of bankruptcy of the limited company (cf. Irrek 1996). The German Ministry of Economy argues that it can be assumed that the nuclear authorities on the state ("Länder") level would have requested such rigorous arrangements in the course of the licensing procedure for the start of operation of a facility. However, in how far this is really the case, in how far stiff letters of comfort are part of the requirements a licensee has to fulfil from start of operation, and in how far these contractual arrangements work in case of a hostile takeover of the mother company could not be fully clarified in the course of this project.

Some German (legal) experts have doubts about the enforceability of the existing contractual arrangements / letters of comfort between the limited companies ("GmbH") and their mother companies in case of a bankruptcy of the limited company and/or its mother company, and about the timely availabitlity of sufficient means of finance in case of an early shut down or investment failures (oral information by some experts; furthermore, cf. the older contributions by Pelzer 1991, Mutschler 1991, Sauer 1991).

Table 9 Base for decommissioning funds required

Short name of nuclear facility	Kind of facility: NPP = nuclear power plant RR = Research reactors Others: please specify	Please check if decommissioning funds are based on overnight / undiscounted decommissioning costs	Please check if decommissioning funds are based on net present value / discounted decommissioning costs	Discount rate used for discounting, if any	Reference date used for discounting	Remarks
All commercially used NPP	NPP	X (commercial law: HGB)	X (IAS/IFRS; US-GAAP)	Different discount rates used in practice, according to IAS 37 and US-GAAP	Depending on cost item	NPP privately owned. In 2005, the NPP operators, which have the status of a limited company (“GmbH”) and operate only one or few NPP, as well as the public companies (“AG”) with NPP (EnBW AG, E.ON AG, RWE AG, Vattenfall Europe AG), submitted their annual financial report (balance sheet and income statement) according to German commercial law (HGB; in addition, AktG for public stock companies). The respective corporate groups EnBW, RWE and Vattenfall Europe submitted their financial report (balance sheet and income statement) according to IFRS/IAS, E.ON according to US-GAAP.
URENCO	Enrichment		X (IAS/IFRS; before 2005: UK-GAAP)		2034 for dismantling, 2104 for tails disposal, 2011 for other provisions	Enrichment facility privately owned.
ANF	Fuel fabrication	X (probably)			?	Not any information accessible.
THTR-300	NPP	X				
All other facilities listed in Table 3	Diverse	X				Other facilities are publicly owned facilities for which decommissioning costs are paid out of the current budget.

Source: Annual financial reports of operators.

Table 10 Decommissioning funds accumulated in relation to expected total costs of future decommissioning of nuclear installations in Germany (2003)

Short name of nuclear facility or operating company	**Kind of facility:** **NPP = nuclear power plant** **RR = Research reactors** **Others: please specify**	**Total decommissioning costs estimated [Mio. Euro]**	**Net provisions accumulated by 31-12-2003 [Mio. Euro]**	**Provisions accumulated in relation to expected costs [%]**	**Years of operation until 31-12-2003 in relation to total expected lifetime [%]**	**Remarks**
E.ON Corporate group	Several NPP (41.7% of total German NPP capacity in 2006)	Information on site-specific cost estimates is not accessible	12,907	Information on site-specific cost estimates is not accessible		2004: 13,481. 2005: 13,362
RWE corporate group	Several NPP (27.1% of total German NPP capacity in 2006)		9,473			2004: 9,012. 2005: 8,675
EnBW corporate group	Several NPP (21.4% of total German NPP capacity in 2006)		3,920			2004: 4,126. 2005: 4,429
Stadtwerke München	Share in KKI 2		679			2004: 552. 2005: 575.
GKN 1	NPP		Information on site-specific provisions is not accessible		81.8	
GKN 2	NPP				44.1	
KKP 1	NPP				72.7	

KKP 2	NPP				55.9	
KKG	NPP				66.7	
KRB-B	NPP				51.4	
KRB-C	NPP				48.7	
KKI 1	NPP				74.3	
KKI 2	NPP				46.9	
KWB A	NPP				82.9	
KWB B	NPP				69.2	
KKE	NPP		1,709		39.5	Kernkraftwerk Lippe-Ems GmbH
KWG	NPP		1,401		55.9	Gemeinschaftskraftwerk Grohnde GmbH + Gemeinschaftskraftwerk Weser GmbH
KKU	NPP		Information on site-specific provisions is not accessible		73.5	
KBR	NPP		1,577		51.5	Kernkraftwerk Brokdorf GmbH
KKB	NPP		1,354		79.4	Vattenfall Europe financial statement. 2004: 1,331
KKK	NPP		1,806		58.8	Kernkraftwerk Krümmel GmbH. 2004: 1,749
KWO	NPP		880		94.6	Kernkraftwerk Obrigheim GmbH
KKS	NPP		1,204		100	Kernkraftwerk Stade GmbH
KMK	NPP		Information on site-specific provisions is not accessible		100	
KWW	NPP	(> 700)	Information on site-specific provisions is not accessible	According to E.ON, provisions should be more or less sufficient	100	Plant was shut down because of economic reasons.

KKR	NPP	3,200	No nuclear provisions because liability is with the Federal government and not with EWN GmbH	0%	100	Special situation of early closure following German unification. Information by the company responsible for decommissioning, Energiewerke Nord (EWN) GmbH. Costs are paid out of public budget.
KGR 1	NPP				100	
KGR 2	NPP				100	
KGR 3	NPP				100	
KGR 4	NPP				100	
KGR 5	NPP				100	
AVR	NPP	ca. 500	Paid out of public budget, therefore 0	0%	100	
KKN	NPP	150			100	Already fully decommissioned
THTR-300	NPP	(444)	?		100	Financing beyond 2009 has to be negotiated between the Federal government, the state of North Rhine-Westphalia and the energy companies having a share in the plant.
MZFR	NPP	275	Paid out of public budget, therefore 0	0%	100	
KNK-II	NPP	291			100	
FRM-II	RR	?			?	Start of operation: 2004/2005. There is no calculation of end of lifetime and expected decommissioning costs yet.
FRJ-1	RR	26			100	
FRJ-2	RR	100			?	
FRG-1	RR	100			?	
FRG-2	RR				100	
FR-2	RR	55			100	
URENCO	Enrichment	No site-specific data accessible. Only data for the URENCO group as a whole: By the end of 2005, URENCO's provisions in the company's balance sheet for all the URENCO sites in total amount to 129 Mio. Euro for tails disposal, 157 Mio. Euro for dismantling of plant and machinery and 19 Mio. Euro for other, also non-nuclear purposes.				
ANF	Fuel fabrication	Information not accessible				

WAK	Reprocessing, complex site	2,230	Paid out of public budget, therefore 0	0%	100	
ITU-JRC	Research facilities	389	Paid out of the EC budget, therefore 0	0%		
Wismut	Uranium mine				100	

Source: Balance sheets of operators; own calculation of expected lifetime based on BfS data.

Table 11 Management of decommissioning funds in Germany (only facilities for which provisions have been accumulated)

Short name of nuclear facility	**Kind of facility: NPP = nuclear power plant RR = Research reactors Others: please specify**	**Provisions accumulated by 31-12-2003 [Mio. Euro]**	**… of which has been accumulated within the own assets of the operator of the facility or its mother company [Mio. Euro]**	**… of which has been accumulated by the operator of the facility or its mother company within a separated account / segregated fund [Mio. Euro]**	**… of which has been accumulated in an external fund under public control [Mio. Euro]**	**… of which has been accumulated in an external fund under mixed private-public control [Mio. Euro]**	**Share of funds the operator of the facility can access for other activities until the funds are needed for their original decommissioning purpose [%]**	**Remarks**
GKN 1	NPP	Information on site-specific provisions is not accessible	100%				100%	
GKN 2	NPP		100%				100%	
KKP 1	NPP		100%				100%	
KKP 2	NPP		100%				100%	
KKG	NPP		100%				100%	
KRB-B	NPP		100%				100%	
KRB-C	NPP		100%				100%	
KKI 1	NPP		100%				100%	

KKI 2	NPP		100%				100%	
KWB A	NPP		100%				100%	
KWB B	NPP		100%				100%	
KKE	NPP	1,709	100%				100%	
KWG	NPP	1,401	100%				100%	
KKU	NPP	Information on site-specific provisions is not accessible	100%				100%	
KBR	NPP	1,577	100%				100%	
KKB	NPP	1,354	100%				100%	
KKK	NPP	1,806	100%				100%	
KWO	NPP	880	100%				100%	
KKS	NPP	1,204	100%				100%	
KMK	NPP	Information on site-specific provisions is not accessible	100%				100%	
KWW	NPP	Information on site-specific provisions is not accessible	100%				100%	
THTR-300	NPP	?						
URENCO	Enrichment	No site-specific data accessible. Only data for the URENCO group as a whole: By the end of 2005, URENCO's provisions in the company's balance sheet for all the URENCO sites in total amount to 129 Mio. Euro for tails disposal, 157 Mio. Euro for dismantling of plant and machinery and 19 Mio. Euro for other, also non-nuclear purposes.						
ANF	Fuel fabrication	Information on site-specific provisions is not accessible	100%				100%	

Source: Balance sheets of operators.

Table 12 Investment of decommissioning funds until they are used for their original purpose in Germany (only facilities for which provisions have been accumulated)

Short name of nuclear facility	Kind of facility: NPP = nuclear power plant RR = Research reactors Others: please specify	Provisions accumulated by 31-12-2003 [Mio. Euro]	… of which have been invested in secure state bonds [Mio. Euro]	… of which have been invested in other assets with fixed interest rates [Mio. Euro]	… of which have been lent to associated or joined companies or to third parties [Mio. Euro]	… of which have been invested in other means (shares, mergers & acquisitions, etc.) [Mio. Euro]	Interest on invested financial means from decommissioning funds in 2003 [%]	Interest on invested financial means from decommissioning funds in period 2000-2003 [%]	Remarks
GKN 1	NPP	Information on site-specific provisions is not accessible	Internal unrestricted funds with no investment requirements. In contrast to pension funds of some of the corporate groups with nuclear facilities in Germany, nuclear provisions are not internally segregated. A direct link from provisions / liabilities made on the right side of the balance sheet to assets on the left side of the balance sheet cannot be drawn.						
GKN 2	NPP								
KKP 1	NPP								
KKP 2	NPP								
KKG	NPP								
KRB-B	NPP								
KRB-C	NPP								
KKI 1	NPP								
KKI 2	NPP								
KWB A	NPP								
KWB B	NPP								
KKE	NPP	1,709							
KWG	NPP	1,401							
KKU	NPP	Information on site-specific provisions is not accessible							
KBR	NPP	1,577							
KKB	NPP	1,354							

KKK	NPP	1,806	
KWO	NPP	880	
KKS	NPP	1,204	
KMK	NPP	Information on site-specific provisions is not accessible	
KWW	NPP		
THTR-300	NPP	?	
URENCO	Enrichment	Information on site-specific provisions is not accessible	
ANF	Fuel fabrication		

Source: Balance sheets of operators.

4 Transparency of the funding schemes to the public - Public information rights

In the course of the **authorisation/licensing procedure** for decommissioning activities, several public bodies and private third parties are involved:

- authorities on federal, state ("Länder") and local level
- consultants
- interested private or public objectors (citizens, associations/NGOs, further stakeholders) in the course of the obligatory participation process, in which several documents describing the planned activities and their expected environmental impact have to be made public (small facilities < 1 kW and with only little impact on environment and health are exempted from this rule).

However, in the course of this procedure, there is not any need for the operators to disclose information on their reasons for choosing a specific decommissioning strategy, or on decommissioning costs or financing as long as the authorities are convinced that the operator is a reliable entity according to the regulations of the Atomic Energy Act. Such information is seen as **company or business secret**. The new consumer information law proposed will not change this situation, since it will cover specific branches only. The operators argue that disclosure of cost and financing information would affect competition.

The **public debate** mentioned in the following chapter of this country report has contributed to the knowledge of journalists and other interested persons and organisations on financing of commercial NPP in Germany. Basic company-specific but not plant-specific information on provisions accumulated is given in financial reports of operators and their mother companies. Furthermore, from time to time, there have been some documented questions and answers on decommissioning financing of publicly-owned facilities in the course of the parliamentary processes on the Federal as well as on the state ("Länder") level.

Therefore, people who would like to inform themselves about the general principles of the funding schemes in place have access to such kind of basic information. However, there is neither any **right** for governments or private citizens to receive any plant-specific information on planned costs or on accumulated provisions for decommissioning of privately-owned facilities, nor has there been any detailed information on decommissioning costs and financing by the private operators yet. Attempts by the German Federal Government to receive more detailed information from the licensees failed.

5 Stakeholder analysis

A **public debate** on the nuclear decommissioning financing system in place for private operators of NPP, and on possible improvements of the current system started in the beginning of the 1990s (cf. Lukes/Birkhofer 1991; cf. also Irrek 1996, Bürger 1998). The different possibilities for decommissioning financing system in principle were already laid out earlier, e.g., in (Lukes/Salje/Feldmann 1978), covering the following possible solutions:

- internal unrestricted funds,
- joint liability of energy companies,
- self-insurance,
- private insurance by third party,
- debt guarantee and
- external state-governed fund.

In preparation of an expected change in government on the occasion of the general election in 1998, politicians of the Social Democrats (Scheer et al. 1997) and the Green Party (Schönberger et al. 1998) had both prepared **draft bills** requiring the transfer of the internal unrestricted provisions of the NPP operators to an external state-governed fund. However, both proposals never entered Federal Parliament, and the discussion on this topic stopped shortly after the red-green coalition took over government. This was due to the fact that fiscal politicians in both parties pushed a **national tax reform** finally implemented in 1999/2000/2002, which directly affected part of the provisions already allocated but did not change the system in principle (cf. Irrek 2001, WI/ÖI 2000).

In the following years, the discussion on possible changes in the decommissioning financing scheme continued on three levels:

- First, after a Committee of experts established by the Federal Ministry for the Environment published a procedure and criteria for the selection of repository sites for radioactive waste (AkEnd 2002), there has been some discussion among legal and nuclear experts who should **finance the search for a deep repository** (cf. Irrek 2004). Today, **NGOs** like Greenpeace Germany still support the idea of an external state-governed fund. Greenpeace, therefore, criticised the former Ministry of Environment, Jürgen Trittin, who proposed a model which transfers the task but also the financing duties of the search for a deep repository to an association of operators of nuclear facilities (“Verbandslastmodell”).
- In a project by the Federal Ministry for Environment, the NPP operators were asked to provide additional information on the financial security of their decommissioning financing system in place. The results of this attempt have not been published yet. Following the discussions and considerations within this project, the GRS has thought about **additional measures to increase financial security** (Steinhauer 2004).

- Third, the discussion took place in the context of **Case T-92/02** some German municipal energy companies brought before the **European Court First Instance** against the European Commission's decision that the German rules under which the operators of nuclear power plants accumulate provisions for future decommissioning do not constitute prohibited state aid within the meaning of Article 87 (1) EC Treaty (cf., among others, Hermes 1999). In January 2006, the European Court First Instance decided at the end of its preliminary examination procedure that there would be no state aid. In April 2006, a consortium of four municipal energy companies, a co-operation of six municipal energy companies and a CHP association has brought an appeal against this decision before the Court of Justice of the European Communities. The consortium plans to convince further municipal energy companies to support this appeal.

While the first two levels of discussion are interlinked and mainly concentrate on the question in how far the existing decommissioning financing system for commercial NPPs in Germany is secure, the third level discusses the question in how far the existing system constitutes state aid distorting competition in the liberalised energy market and is not the topic of this project.

One important consequence of the mutual agreement between Government and NPP operators of 14 June 2000 is, that today, there is hardly any policy space left for changes in the current decommissioning financing system of privately-owned nuclear installations anymore. Furthermore, the **German Federal Government** seems to be fully convinced

- that the existing decommissioning financing system in place is functioning well in principle,
- that the existing European directives 78/660/EWG and 83/349/EWG would be sufficient to require the Member States to implement well-functioning regulations with regard to the annual financial statements of private companies, and,
- that at most minor improvements of the existing German decommissioning financing system – e. g., with regard to the transparency of the system / information rights - would be sensible (cf., e.g., the questionnaire filled in by the German government in the course of the DG TREN project carried out by Colenco and Iberinco, and the Government's position in the Case T-92/02 mentioned above).

6 Conclusions and recommendations

Financial security of the German decommissioning financing system can be assumed as long as

- technical and economic know how and capacities allow detailed realistic cost estimates based on experiences with decommissioning activities already completed,
- the liable licensees strictly follow general accounting principles and the prudence principle of the German commercial code,
- financial risk management systems of the liable licensees and their mother companies are functioning,
- audits by certified auditors are effective,
- sanctions which are foreseen in the German commercial code and in the regulations regarding risk management and the role of auditors are deterring
- contractual agreements / letters of comfort between limited companies ("GmbH", being responsible for one or two NPP only) and their mother companies (corporate groups they belong to) are rigorous enough even in the case of a takeover of the mother company by a third party, or a rigorous link to the mother company is already part of the operator's license,
- the mother company / corporate group or an external third party has a sufficient amount of assets at its own disposal which can be timely converted into cash in order to pay for decommissioning expenditures whenever this is needed, i. e. that the licensees invest the financial equivalent of the nuclear provisions into assets matching maturities of the respective nuclear liabilities and receive a sufficient payback, and,
- there are no severe incidents or accidents or other unforeseen events which cannot be covered by the existing compulsory cover / liability insurances ("Deckungsvorsorge"), or by the provisions made and assets accumulated.

Because of the problems that might occur with such an internal unrestricted fund as it is implemented in Germany, the Wuppertal Institute has always recommended to install an effectively governed independent **external fund** (ring-fenced fund). Legal expertise can demonstrate that such an external fund would be in compliance with German Constitution (Irrek 1996, von Mutius 1996, Gaßner/Lorenzen 2006). Several suggestions to completely transfer the existing provisions to an external fund or to improve the current system have been made since the beginning of the 1990ies (cf., e.g., the respective contributions in Lukes/Birkhofer 1991, Scheer et al. 1997, Schönberger et al. 1998).

If the current decommissioning financing system in Germany were maintained, several experts recommend to think at least about the implementation of **additional regulations and restrictions** with regard to (cf., among others, the proposals by Steinhauser 2004, Pelzer 1991, Mutschler 1991, and Sauer 1991)

- the **disclosure of information** (e. g., central collection of data and information on liabilities, costs and provisions; benchmarking of costs per typical decommissioning activity; control by public information and discussion)
- a possible **bankruptcy of the licensee** (additional regulation within the decommissioning license procedure; “stiff” letters of comfort / contractual regulations between limited companies and their mother companies / corporate groups they belong to; maybe further guarantees or a guarantee pool), and,
- the **investment of internal funds** by private companies (e. g., an ordinance on how to invest in assets similar to the respective ordinance in place for insurance companies).

These are just some preliminary conclusions based on the analysis of the German decommissioning financing system. More detailed recommendations for the European level and the European Member States will be developed within the final report of this project following the considerations of a detailed financial risk analysis.

7 References

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